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GB 2283694 A GB 1532409 A EP 0193000 A

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Online databases: EDOC, JAPIO, WPI

(54) Centrifugal separator

(57) A centrifugal separator (10, Figure 1) for separating solid particles from a liquid, eg engine lubricant, includes a rotor container (20) to which the liquid is supplied at elevated pressure and caused to escape via tangentially directed nozzles (28) to create high speed rotation of the rotor and centrifugal separation forces within the liquid. In order to avoid problems of noise and vibration when the rotor empties as it spins to rest, it is characterised by a check valve (40) incorporated between separation and outflow chambers (36, 37) of the rotor which makes use of the normally conical shape of the partition wall (35) between the chambers that defines a central, annular, transfer aperture (39). The check valve includes a body (41) disposed to overlie, be biased towards and seat against, the inclined face of the partition wall to form a low flow-resistance valve from parts cheap enough to dispose of with the rotor.

Notwithstanding the ability for low cost manufacture, the check valve is able to provide a good seal that retains liquid in the separation chamber, not only reducing wind-down noise but also enabling the centrifugal separator to commence working more quickly after frequent engine stops, and on both counts is particularly suited to passenger car engines.

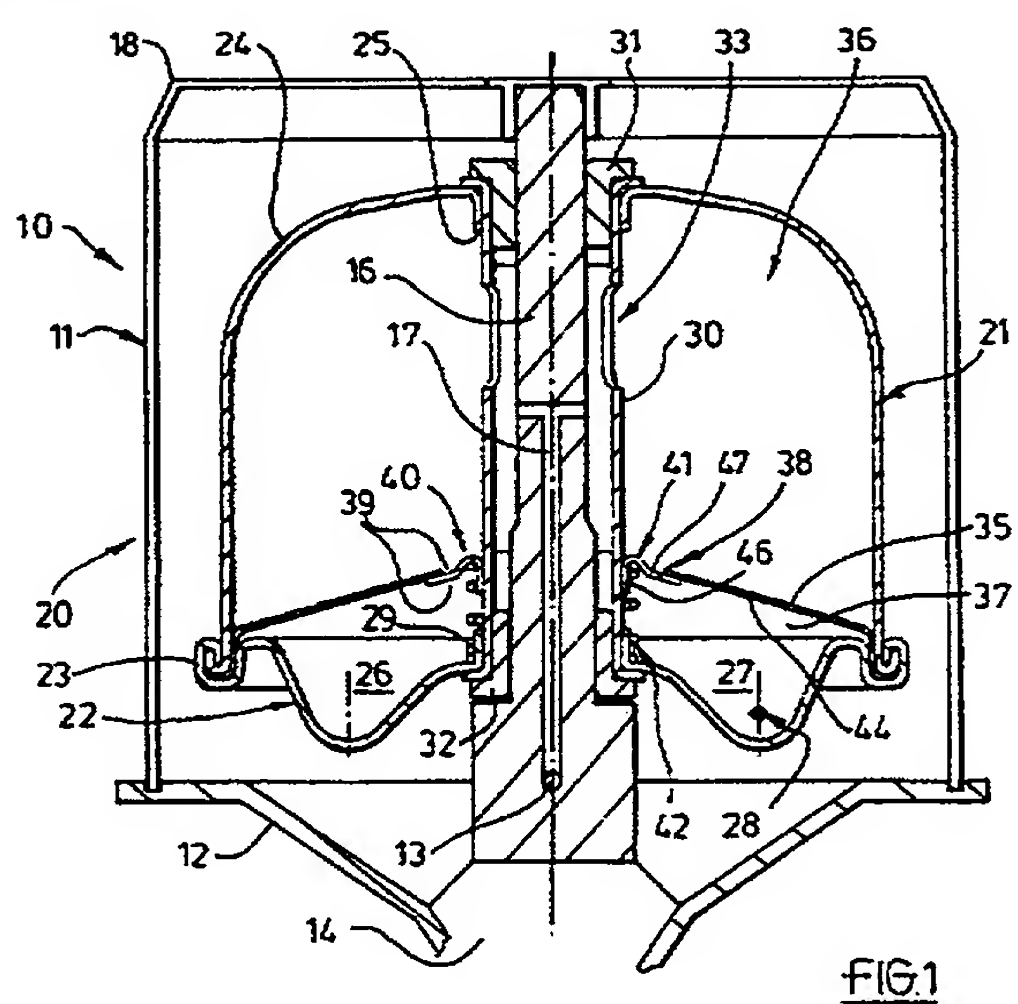

FIG.1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1995

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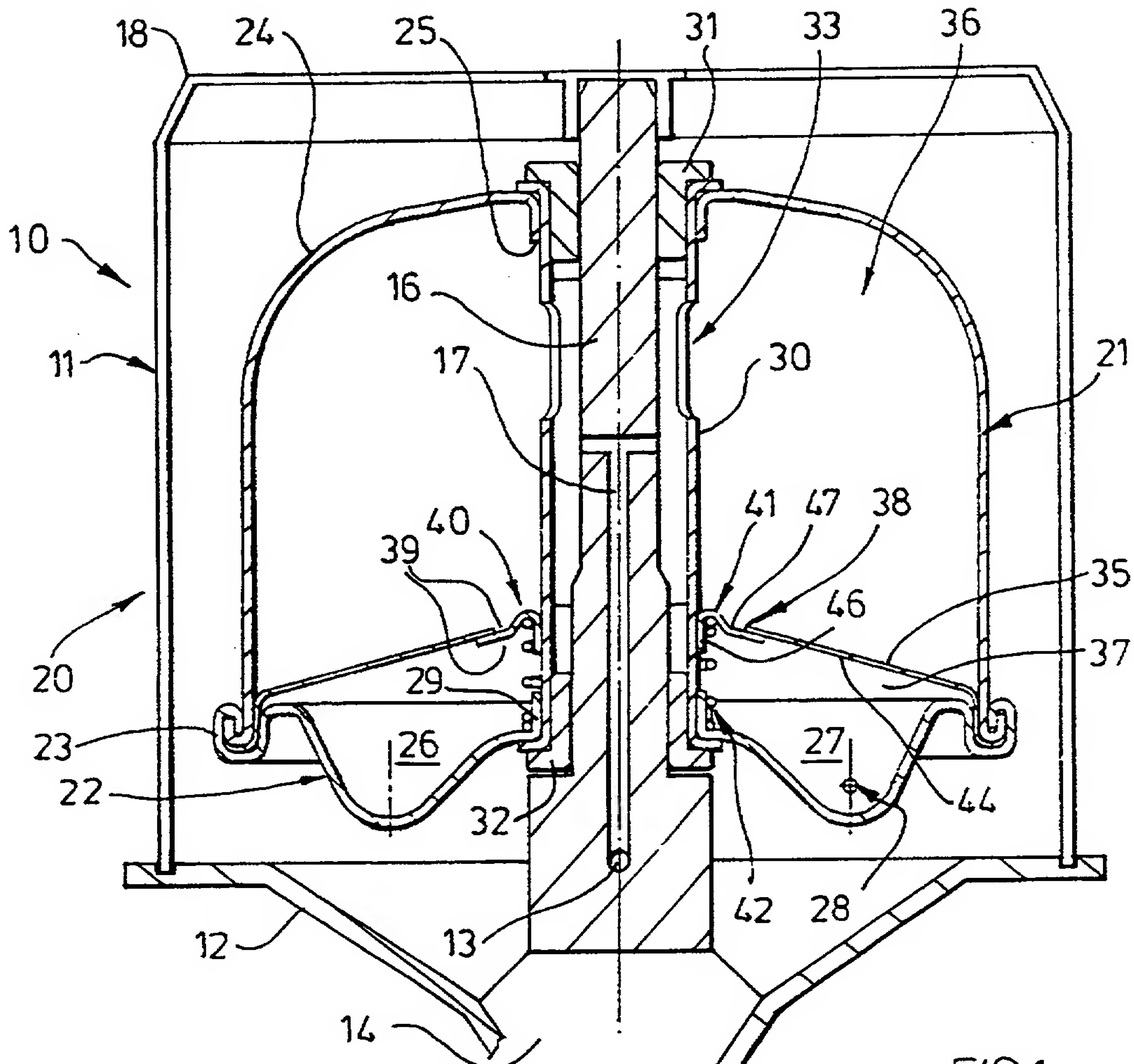

FIG.1

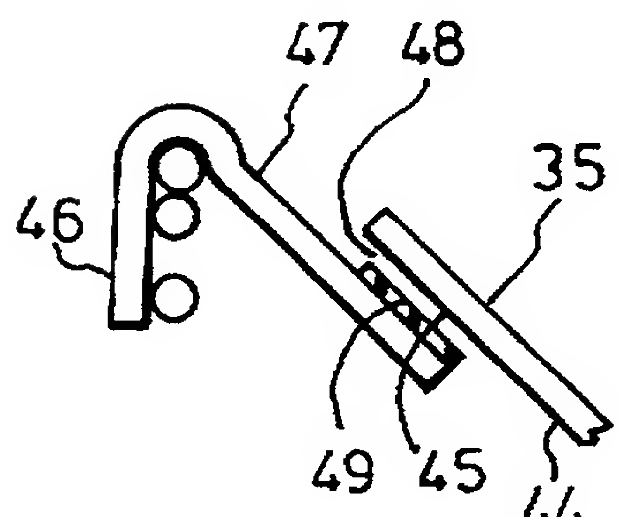

FIG.2

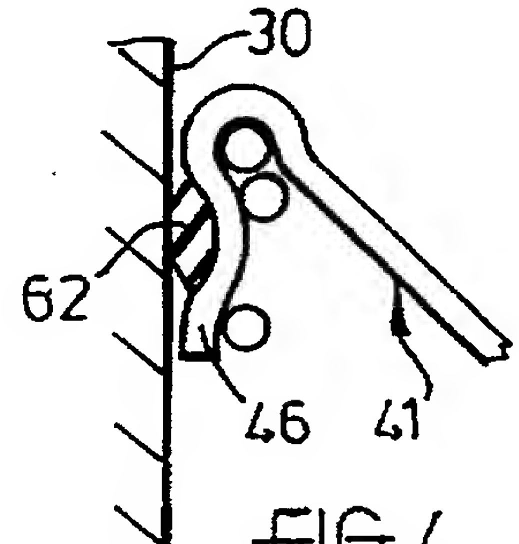

FIG.4

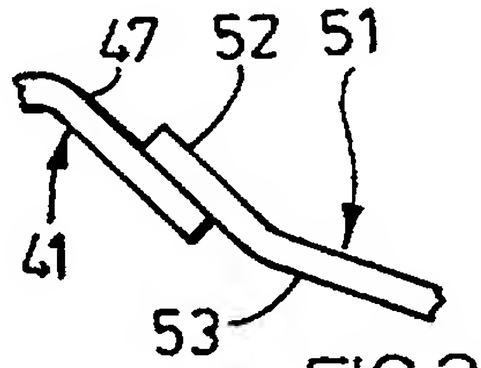

FIG.3(a)

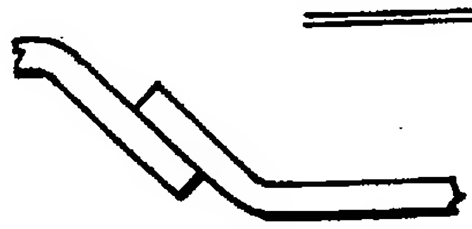

FIG.3(b)

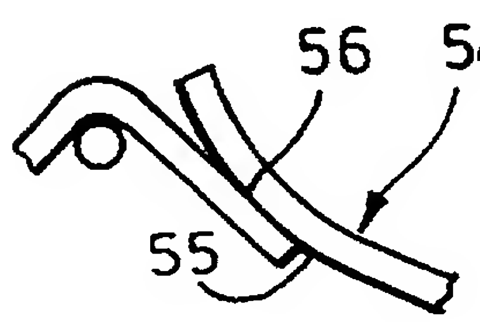

FIG.3(c)

FIG.3(d)

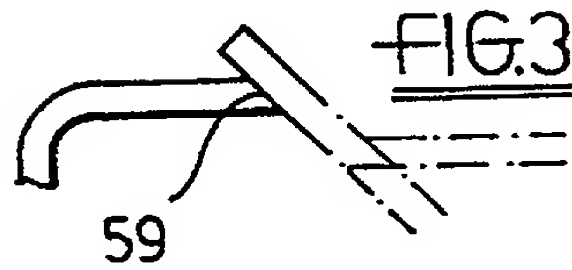

FIG.3(e)

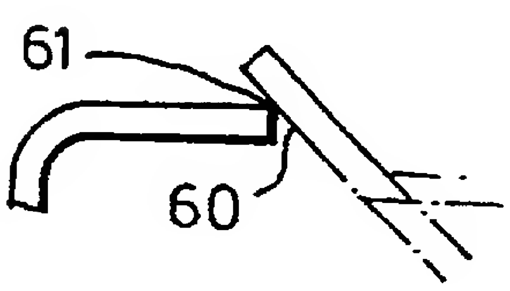

FIG.3(f)

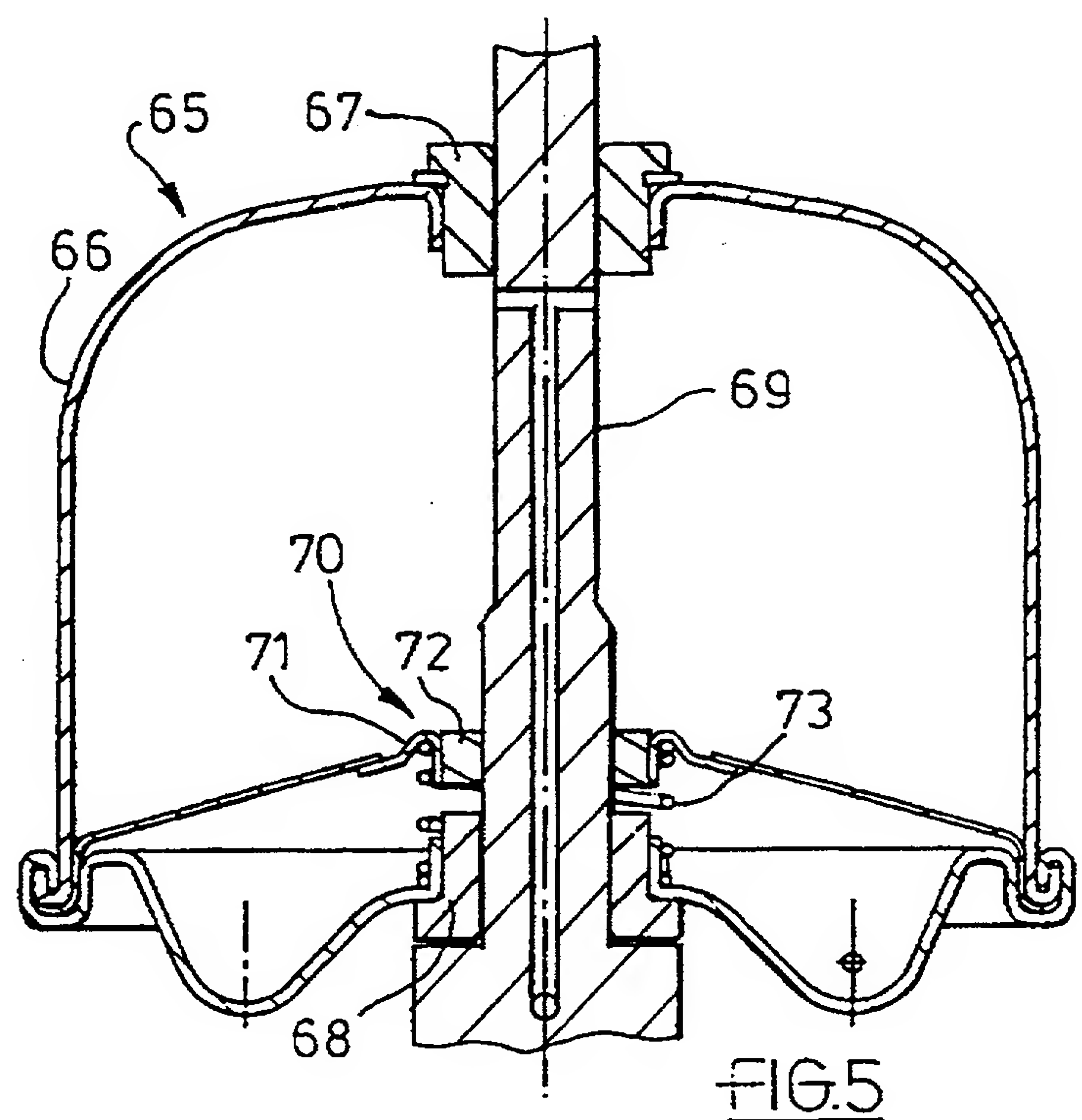

FIG.5

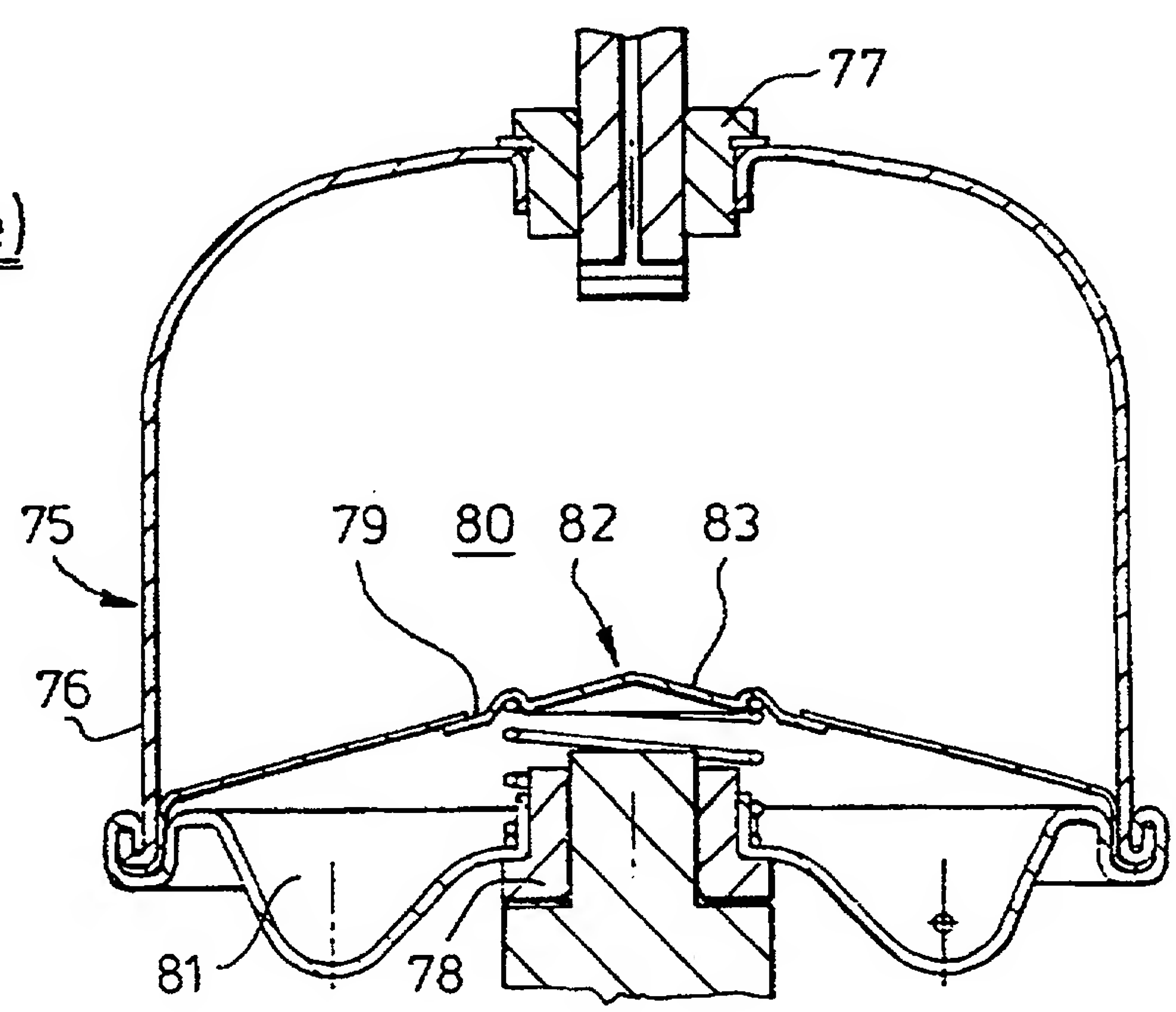

FIG.6

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Centrifugal Separator

This invention relates to centrifugal separators of the self-powered kind for separating particulate contaminants from a liquid, such as a vehicle engine lubricant, within a containment rotor to which contaminated liquid is supplied at elevated pressure, and particularly, but not exclusively, relates to low-cost disposable rotors for use with passenger automobile engines.

Self-powered centrifugal separators are well known for separating fluids of different densities or for separating particulate matter from liquids and have long been used in lubrication systems for engines and analogous items of vehicles. Such devices are described in, for example, GB 735658, GB 757538, GB 2160796, or GB 2383194.

The common principle of operation is that a housing contains a rotor which is supported therein to spin at high speed about a substantially vertical axis. The rotor comprises a container to which contaminated liquid lubricant is supplied at elevated pressure along the axis of rotation at one end of the rotor and is ejected from tangentially directed reaction jet nozzles at the other end of the rotor into the housing from which it drains to the engine sump. The energy lost by the ejected liquid effects rotation of the rotor about the axis at a speed, in excess of 8,000 rpm, fast enough for the liquid circulating in, and passing through, the rotor to deposit solid contaminants on radially outward surfaces. For efficient separation, and to ensure that separated contaminants do not interfere with the reaction jet

nozzles, the rotor container is provided with a radially inwardly extending partition wall that effectively divides the rotor into a separation chamber, in which the solids collect, and an outflow chamber, to which the cleaned liquid passes by way of a transfer aperture sited near the rotation axis. It is common in modern designs, such as, EP 0193000 and GB 2283694, for this partition wall to extend both radially and axially as what is sometimes referred to as a separation cone, which better holds solids and liquid-containing sludge within the separation chamber if the rotation axis is tilted from the vertical.

There are several criteria associated with successful operation. Lubricant supplied to the rotor has to be available at a significant pressure if the energy lost by its passage through the reaction jet nozzles is to be sufficient to rotate the rotor fast enough to effect centrifugal separation of said contaminated particles. Also, of course, the lubricant passed through the centrifugal separator loses substantially all of its energy in effecting rotation by jet reaction, that is, it is returned directly to the sump and by-passes the normal lubrication utilisation circuits of the engine, so that the centrifugal separator operates in a so-called lubricant by-pass mode. Consequently, there is normally incorporated in the lubricant supply system a pressure responsive valve which inhibits the flow of lubricant to the centrifugal separator when the supply pressure is below a predetermined level at which the engine might be starved of lubricant if any were diverted and at which the rotor would not operate efficiently even if supplied.

Such a centrifugal separator is normally associated with a conventional full-flow, or through-flow, filter (although the small particle separation capabilities of the centrifugal separator enables a rather coarser mesh filter to be used than otherwise) and it is often arranged that both filter and separator are mounted on a specially designed interface which includes supply ducts and pressure responsive flow control valves, for exampl as shown in GB 2160449 and GB 2160796.

Diesel engines are particularly well suited to this form of lubricant cleaning, because of problems of small, light particles in the lubricant that result from combustion products and the generally longer intervals between servicing operation than has been normal with gasoline engines. Thus the combination of a coarse mesh, full-flow filter and centrifugal separator is particularly suited to operation of, and has been widely adopted with, commercial vehicles to maximise intervals between servicing operations.

More recently, it has become popular to include similar diesel engines in small passenger vehicles and, irrespective of engine type, for there to be longer intervals between servicing at which lubricant and/or filter elements would be changed, it being conventional now in relation to passenger vehicles that contaminated components of such filter elements are disposable rather than cleanable by the servicing mechanic, who is frequently the vehicle owner.

Thus it follows that in adapting the concept of supplementing a full-flow filter with a centrifugal separator to such small passenger vehicles, the rotor, when it does eventually fill with contaminant, should be disposable and replaceable with a new one rather than cleaned, and notwithstanding the increased interval between replacements, the disposable rotor must be a low cost item. To this end low cost disposable rotor designs exist, for example EP 0193000, and GB 2283694 which rely upon the rotor being formed as a canister from pressed sheet materials.

However, it is found that centrifugal separators, particularly those of such a pressed sheet construction, exhibit characteristics peripheral to their separation functionality which may militate against ready acceptance within the small passenger vehicle environment.

In such passenger vehicles, although the passenger compartment is much closer to the engine and its ancillary components, there is required a much lower noise level than for commercial

vehicles. Whereas any additional noise level caused by a spinning centrifugal separator rotor may be considered minimal in terms of passenger perception whilst the engine is running, it is found that an increased noise level continuing after the engine is stopped is particularly objectionable.

When the engine is stopped the centrifuge rotor, which may be spinning in excess of 8,000 rpm, continues to rotate for a considerable deceleration or wind-down period that may be in the range of 30-60 seconds, depending upon the supply pressure and temperature of lubricant passing therethrough, and during that wind-down period the noise level may increase as the rotor empties of lubricant and exhibits bearing contact and out-of-balance vibration as the speed falls and the bulk of the liquid moves about within the partially filled container.

It will also be appreciated that each time the engine is stopped not only does the decelerating rotor create a vibration and noise nuisance as it decelerates to rest and empties but also the emptying has a consequence in that when the engine is next started the rotor has to refill with lubricant before it can commence rotation and become active. As the small passenger vehicle engine can be expected to be started and stopped more frequently, and run for much shorter intervals, than has become the norm with commercial vehicles, the maximum benefit of centrifugal separation may not be obtained in such small passenger vehicles.

It will furthermore be appreciated that the rotor does not empty completely in winding down to rest as the partition wall, particularly if having an axial extent, traps some lubricant with the contaminant sludge. It is found that when such a nominally empty rotor is lifted from the housing and tilted, this liquid tends to enter the outflow chamber and escape by way of the reaction nozzles. Whereas the quantity of liquid to escape is small and the escape is not particularly significant per se, th fact that it is ejected via the tangential nozzles frequently

results in it being directed unexpectedly at the person handling the rotor or over adjacent equipment.

Thus adopting the use of centrifugal separation to the lubrication system of small passenger vehicles is seen to present its own set of requirements, namely, the rotor should be a disposable container, relatively clean in respect of evacuating trapped materials during disposal, quiet in wind-down after the engine has stopped, begin to operate as soon as the engine runs and of cost effective form.

Apart from the issues of cost, it will be seen that most of the undesirable effects result directly from lubricant draining from the rotor during wind-down or if tilted after wind-down.

Thus a two-fold benefit is seen to be gained from having in a centrifugal separator for a small passenger vehicle a rotor which does not empty of lubricant each time the engine is stopped, within the constraints of such rotor being a cheap disposable item, namely reduction in wind-down noise and cleaner disposal.

Thus there is perceived to be a requirement for some valve arrangement to retain at least a major proportion of the lubricant within the rotor container when the engine is stopped, it being most important that whatever is retained, and not allowed to leave during wind-down, is properly and securely held within the container unless and until it is desired to remove it, and then to such removal being well-behaved.

Although it is conventional, as mentioned above, to dispose a flow inhibiting valve, for conventionally preventing supply of lubricant to a centrifugal separator and by-passing the engine when the supply pressure is not high enough, GB 1532409 unconventionally disposes such a flow inhibiting valve within the rotor of the centrifugal separator. In the arrangement described therein, a full flow filter element and centrifugal separator are contained together within a single housing, the full flow filter furth rmore being physically secured to the rotor of the

centrifugal separator for rotation thereby and therewith. A common supply duct actually supplies lubricant to the centrifugal rotor before the full flow filter, although both inlets are physically close, so that the necessary pressure-responsive flow inhibitor valve which prevents the by-pass separator from depriving the full flow filter and engine of lubricant at low pressure is formed within the rotor of the centrifugal separator. Although its location is unconventional, its purpose and function is conventional in preventing lubricant available only at low pressure from by-passing the full-flow filter and engine.

The valve is of a simple design, comprising a plate-like valve body biased towards a seat formed by the edge of a downturned lip of the partition wall between separation and outflow chambers so as to stem the flow of lubricant between them.

It will be appreciated that as the aim of the valve is to prevent wholesale by-passing of the full-flow filter, the valve does not require to exhibit particularly good sealing properties and the crude arrangement of valve body and valve seal is adequate for the purpose of inhibiting large scale flow when some, but modest, supply pressure exists.

Whereas the prior art indicates where a pressure responsive valve may be disposed within a rotor of a centrifugal separator a useful and cost-effective solution to the problem of wind-down noise within an inexpensive disposable container of a centrifugal separator is only achieved if such a valve truly checks the flow of, that is, retentive of, liquid lubricant and cheap enough to build into, and dispose of with, the container.

It will be appreciated that any such solution to wind-down noise and handling in relation to disposable rotor containers is applicable to a greater or lesser extend to non-disposable, that is, cleanable, rotor container forms.

It is an object of the present invention to provide for a self-pow r d centrifugal separator a rotor which has separation and

outflow chambers defined therein by a partition wall and a pressure-responsive flow check valve having good sealing ability of simple and cost effective form.

According to the present invention a self-powered centrifugal separator rotor comprises a container operatively rotatable about a rotation axis extending therethrough, the container having an outer peripheral wall, an internal partition wall extending radially inwardly from the peripheral wall dividing the container into a separation chamber and an outflow chamber and defining at its radially inner periphery a transfer aperture between the separation and outflow chambers, said separation chamber including an inlet port to admit liquid thereto from the rotation axis and the outflow chamber having at least one tangentially directed reaction jet nozzle to eject liquid from the container, and a pressure responsive check valve operable to close the transfer aperture when the pressure of liquid in the separation chamber is below a predetermined value, the valve comprising a valve body contained within the outflow chamber, bias means operable to bias it in an axial direction towards the transfer aperture and a valve seat formed by the partition wall, the partition wall having at least a portion thereof, surrounding the transfer aperture, formed with the face thereof defining the outflow chamber inclined with respect to the rotation axis at an acute angle such that the said face forms a seating region for the valve body, the valve body comprising a radially extending face disposed overlying said transfer aperture and seating region and defining therebetween a valve passage which includes said inclined face of the partition wall, said body being responsive to said bias means to abut said seating region of the face to close said valve passage.

The partition wall surrounding the transfer aperture and forming the seating region may be inclined at a constant angle along its radial length, that is, in a conical manner, or curved and presenting a convex surface to the outflow chamber.

Th partition wall radially outwardly of th seating region may

continue at the same or different inclination, or even orthogonal to, the rotational axis.

The valve body may contact the seating region with a valve face comprising a peripheral edge of the body but preferably comprises a surface inclined to the rotation axis. In an elevational plane extending through the rotation axis, one of the valve faces or seating regions may be convex whilst the other is substantially flat, seating contact being confined to a radially narrow region offering maximum sealing pressure, or both face and seating region may be flat and seating effected over a radially significant extent. In either case, because of the generally conical nature of the transfer aperture, and valve passage, the valve body is able to seat properly against the partition wall without the necessity for strict dimensional tolerances in their dimensions, provided concentricity is preserved.

The surface of the valve face and/or seating region may be coated with a resilient seal enhancing material or carry a separate seal member; alternatively the valve body and/or partition wall materials themselves may be prepared to a standard of surface finish which permits (possibly in conjunction with a significant area of seating) a good liquid-tight seal.

Conveniently the partition wall and valve body are pressed steel sheet components, although other materials may be employed if desired.

The rotor may have at least in operation within a separator, a cylindrical member extending along its axis between spaced bearings in the peripheral wall, defining a radially inner peripheral wall for both chambers of the rotor and about which member the transfer aperture takes an annular form. Correspondingly the valve body takes an annular form which is slidable along the member.

The valve body may have an axially extending sleeve part which is mated with the cylindrical member to provid a precision

sliding fit that is substantially liquid-tight, at least to lubricant, between its ends, or a compressible ring or wiper seal may be disposed between the valve body and such axially extending member, possibly carried by the valve body.

In a form of centrifugal separator in which such axially extending cylindrical member is fixed with respect to the peripheral wall of the rotor to rotate therewith about a static spindle which extends along the member, the valve body is required only to be displaceable axially with respect to the member. In another form of centrifugal separator in which the bearings at each end of the rotor are arranged to receive a static spindle which forms a radially inner wall to the rotating rotor, the annular valve body has its radially inner surface formed as a bearing capable of both rotational and axial movement with respect to such spindle.

A rotor of the type having an axially extending hollow cylindrical member fixed with respect thereto, employs the member as a spacer and a carrier for the bearings, in the form of metallic bushes pressed into the ends thereof, to ensure that the bearings remain in axial alignment before and during operation. In order to produce a precision fit between the spacer member and the sleeve of the valve body, it is relatively simple in manufacture to expand the region of the spacer to be surrounded by the valve by an internally applied force to a tightly defined value matched to the internal diameter of the particular valve member, notwithstanding that the spacer member, as a member, is not initially manufactured as a precision item.

Notwithstanding the improved form of check valve achieved with minimum modification to essentially well known forms of rotor designs, it will be seen that such a valve having the fluid directed therethrough in such a way that it flows smoothly along the inclined face of the partition wall minimises any turbulence or impedance to normal flow that would detract from the rotational ffici ncy of th rotor.

It will be appreciated that within a particular engine, and particularly a small passenger vehicle engine, the lubricant supply pressure is usually in the range of 4 to 5 bar and that for maximum efficiency requires minimal loss of pressure before the reaction jet nozzles. Thus although the presence of any pressure-responsive valve clearly has such a pressure drop associated therewith such a valve is necessary per se to prevent by-pass of lubricant in the wrong circumstances.

The simple design of valve in accordance with the present invention permits, by choice of bias force, such pressure drop to be kept to a minimum for different forms of separator arrangement.

By having the pressure responsive check valve within the rotor, the need for an external valve is obviated and a centrifugal separator arrangement or lubricant conditioning system of which it is part may be designed or modified to remove such external valve. Accordingly the liquid admitted to the rotor container is at a slightly increased pressure than otherwise and the erstwhile pressure drop of the pressure-responsive valve (necessary to detect undesirable by-pass conditions) now occurs between the two chambers, leaving the pressure in the outflow chamber substantially unchanged but with the added provision of flow check from the separation chamber.

If it is not practicable to remove such external pressure responsive valve, and liquid is prevented from admission to the rotor when the pressure is below the safe minimum, then the internal pressure responsive check valve is required only to respond to the presence or absence of lubricant supply, that is, engine running or engine stopped. Accordingly, the valve bias means may apply a very low force such that the valve is readily opened in operation, and thus introduces little pressure drop, whilst being able to close rapidly when lubricant pressure drops totally upon engine stoppage.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings, in which:-

Figure 1 is a sectional elevation through a rotor of a centrifugal separator arrangement having inter alia a central tubular spacer member, the rotor including a first form of pressure responsive flow check valve in accordance with the present invention,

Figure 2 is a sectional elevation through the fragment of the valve encircled in Figure 1 showing the valve structure thereof in greater detail and flow path of liquid through the open valve,

Figures 3(a) to 3(f) are fragmentary sectional elevations similar to Figure 2 of corresponding parts of different forms of valve in accordance with the invention,

Figure 4 is a sectional elevation through a valve of any of the above forms but including a sealing element between the valve body and spacer member,

Figure 5 is a sectional elevation through a different form of rotor having no central tubular spacer member, but in operative disposition with respect to a stationary spindle extending therethrough, including a further form of pressure responsive check valve in accordance with the present invention which co-operates also with the spindle, and

Figure 6 is a sectional elevation through a different form of rotor, having no central support tube, but including a further form of pressure responsive check valve in accordance with the present invention.

Referring to Figures 1 and 2, a self-powered centrifugal separator arrangement for a vehicle engine, particularly a small passenger vehicle, is indicated generally at 10. The separator is empl yed in conjuncti n with a full flow filter (not shown) in maintaining the engine lubricant free of potentially damaging

contaminants. Lubricant is pumped around the engine by a pump (not shown) whose delivery pressure is regulated but also, to a limited extent, dependent upon engine speed and lubricant temperature.

The separator arrangement 10 comprises a housing 11 in the form of a support structure 12 coupled to the engine to receive pumped lubricant by way of supply duct 13 and return it to the sump by way of drain duct 14, thereby by-passing the engine components which use the pumped lubricant. The support structure 12 has fixed thereto a substantially vertically extending spindle 16 which has a passage 17 extending at least part way along and coupled to the supply duct 14 at its lower end. The upper end of the spindle is secured to, and secures, a housing lid 18 releasably sealed to the support structure 12.

A rotor 20 is mounted within the housing for rotation about the spindle 16. The rotor is substantially conventional in comprising a container formed from pressed streel sheet components 21 and 22 jointed at a folded seam 23. The component 21 has a peripheral wall 24 which extends radially inwardly at one end of the rotor to an aperture 25. The component 22 forms a substantially radially extending base in which are found recesses 26, 27 containing a pair of tangentially direction jet reaction nozzles, one only of which is visible at 28, the base component being apertured at 29 in line with aperture 25 on the longitudinal axis of the rotor.

A hollow member 30 extends between and through the axially spaced apertures 25 and 29, being swaged to the container components to act as a spacer for the end walls and a receptacle for bearing bushes 31 and 32 which support the rotor for rotation about spindle 16, the longitudinal axis of the rotor therefore being synonymous with the rotation axis of the rotor.

The spindle passage 17 opens into the spacer member, which is apertured at 33 to admit liquid lubricant at supply pressure to

the container from the rotation axis. The spacer member 30 thus forms a radially inner wall for the container.

Within the container, internal partition wall 35 extends radially inwardly from the peripheral wall at the seam 23 and divides the container into a separation chamber 36 (in which contaminants are separated from the liquid lubricant) and an outflow chamber 37 in communication with the reaction nozzles, 28 etc. The radially inner periphery 38 of the partition wall defines a transfer aperture 39 between the separation and outflow chambers 36 and 37. The partition wall 35, although extending radially inwardly is also inclined with respect to the rotation axis at an acute angle being frusto-conical in elevation, the arrangement serving to inhibit solid contaminants which tend to collect within the radially outer peripheral wall from falling into the outflow container with attendant risk of reaction nozzle blockage or return to the lubricant sump. To this end, such an inclined partition wall is frequently called a separation cone.

The rotor as thus far described is essentially conventional.

In accordance with the present invention, the rotor includes a pressure responsive flow check valve indicated generally at 40 comprising a valve body 41 contained in the outflow chamber, bias means 42 operable to bias it in an axial direction towards the transfer aperture and a valve seat formed by the partition wall. The lower face 44 of the partition wall, that is, the face thereof defining the outflow chamber, is inclined with respect to the rotation axis and in a region 45 surrounding the transfer aperture forms a seating region for the valve body, the seating region extending therefrom both circumferentially about the axis and radially.

The valve body 41 is annular and surrounds, and forms an axially sliding fit on, the tubular spacer member 30. The body comprises a cylindrical bush part 46 which extends axially and a radially ext nding valve fac 47 which overli s the transfer aperture and seating region of th partition wall , having a frusto-conical

form corresponding to the partition wall in terms of inclination with respect to the rotation axis. The valve body and partition wall thus define between them a valve passage 48 which extends along said inclined face.

In an elevational plane extending through the rotation axis, as in Figure 2, the valve face is a radially extensive surface which extends parallel to the seating region 45 such that as valve body is biased towards the transfer operative, the two surfaces abut over a significant area to close off said valve passage with a significant wedging action which follows from the inclination.

Conveniently, one or both surfaces are provided with a thin coating of resilient seal-enhancing material 49, although if desired the surfaces forming the valve face and seating region could be manufactured to a surface finish which provides good sealing for liquid lubricant. Conventionally, the partition wall is formed from pressed sheet steel and it is convenient to manufacture the valve body from the same material and by the same method, although this need not be so and other materials may be chosen which together have better inherent sealing ability at the seating surface.

Depending upon whether or not there is a pressure-responsive flow-inhibiting valve elsewhere in the lubrication system or centrifugal separator arrangement, the bias spring may have a low rate such that the bias is overcome by any positive pressure in the separation chamber or may have a rate corresponding to a minimum pressure at which the lubricant by-pass through the arrangement is to be stopped.

In operation, when lubricant is admitted to the separation chamber and the pressure therein exceeds that on the outflow chamber by an amount related to the strength of the valve spring 42, the valve body is depressed axially and separates the valve face 47 from the seating region 45, creating said valve passage 48 and permitting th lubricant to flow smoothly thr ugh the valve passage along the faces of the valve body and partition

wall without introducing sharp changes in flow direction or encountering obstructions to flow which can lead to unnecessary turbulence and have the effect of a pressure drop across the valve over and above that which is inherent in the bias.

When the engine is stopped and no further lubricant is supplied, the valve 40 closes absent positive pressure within the outflow chamber the rotor begins to decelerate; the outflow chamber may or may not drain, depending upon the ingress of air by way of the reaction nozzles. The separation chamber may drain to some extent by way of the supply port 33, depending upon any back drainage along the supply duct. However in the main, and for the wind-down interval, the separation chamber remains substantially filled with lubricant and it is found that even if not completely filled, if a constant level is reached and maintained, vibration modes which result from lubricant movement of a changing level, are diminished. Clearly if the engine is restarted, the separation chamber is readily refilled and operation of the centrifugal separator can commence almost immediately.

If the rotor is removed from the housing then the liquid contained within the separation chamber can be simply and safely removed by tilting the rotor such that the lubricant exits by way of the inlet port 33, and the spacer tube where one exists.

It will also be appreciated that the efficiency of centrifugal separation is dependant upon the dimensions of the transfer aperture in relation to flow rate, as set out in the aforementioned GB-A-2283694. It will be understood that the valve passage 48 is for most purposes smaller than the annular aperture within the partition wall. Therefore the position of the valve passage, as effective transfer aperture, may be displaced radially from the spacer member permiting significant choice in the area of valve face exposed to separation chamber pressure.

The form taken by the valve 40 in Figures 1 and 2 is particularly convenient in making use of an already existing, inclined frusto-

conical partition wall, but other forms are possible as illustrated in Figures 3(a) to 3(f) which are fragmentary sectional elevation views corresponding to Figure 2.

In Figure 3(a) the partition wall 51 is inclined at its radially inner part 52, where the seating region is defined, at a different angle to be the part of the wall 53 radially outwardly thereof, the angle of each conical section being chosen with respect to optimising its function.

In fact, as illustrated in Figure 3(b) the partition wall need not be inclined to the rotation axis except in the vicinity of the transfer operative where the seating region is defined.

As shown in Figure 3(c) the seating region 54, which is inclined to the longitudinal axis, need not be formed as a conical surface which appears flat in an elevational plane, but may be formed as a progressive or curved inclination, presenting a convex face 55 to the outflow chamber and seating region 56 to the 'flat' valve face. The valve face contacts the seating region over a reduced area but with correspondingly increased seating pressure, the overall conically tapering nature of valve having the ability to provide a good closure without forming the valve body and partition wall as an accurately matched pair, as long as they are concentric. The relationship between curved and 'flat' surfaces may be reversed, as shown in Figure 3(d) when the seating region 57 is formed on a flat, frusto-conical partition wall part and the valve body is formed with an upwardly convex face 58 to contact the seating region.

Whereas the seating region is defined by a radially extensive, inclined lower face of the partition wall, the cooperating face of the valve body may be formed other than a radially extensive upper face of such a pressed sheet valve body. Referring to Figure 3(e) the valve body is shown as having a valve face 59 defined by a chamfered edge of a generally radially extending valve body, said fac being parall l to the seating region on the

lower face of the partition wall and operable to make contact over a finite, but restricted, area.

Alternatively, and as shown in Figure 3(f), the valve body may have its abutment with seating region 60 of the partition wall defined by a sharp edge 61 which is arranged to make a line contact around the seating region.

Other forms of valve face and seating region combinations may be applied which follow the criteria set out above for the seating region of the partition wall.

As described above, the axially extending bush portion 46 of the valve body is able to form a substantially liquid tight seal with respect to the spacer member if it is a precision fit on the latter. The valve body may be simply pressed or moulded to shape and reamed to a predetermined size if necessary. The spacer member, which is expanded radially outwardly to become swaged to the bearing bushes, may be similarly expanded by insertion of a suitably dimensioned former to give an outside dimension corresponding to, and forming a precision fit with, the valve body bush.

Alternatively, or additionally, and as illustrated in Figure 4, a specific sliding sealing element 62 may be disposed between the valve body and the spacer member (being carried by either) to prevent seepage of lubricant.

The various forms of valve arrangement described above have been for a rotor structure including a tubular spacer member 30.

Referring to Figure 5, this shows a sectional elevation through a similar centrifugal separator arrangement 65 but on which the rotor 66 has no such spacer member and bearing bushes 67 and 68 are individually mounted in the rotor wall. The static spindle 16 extends axially between and through the bearing bushes providing a non-rotating radially inner peripheral wall of the rotor. The pressure responsive flow check valve 70 is

substantially as described above except that the axially extending bush part 71 includes a bearing bush 72 permitting it to rotate on the spindle with the rotor, to which it is attached by (at least) bias spring 73 and move axially with respect to the rotor when opened by liquid pressure in the separation chamber.

Referring to Figure 6, this shows a sectional elevation through yet another form of centrifugal separator arrangement 75 in which the rotor 76 is supported at upper and lower bearings 77 and 78 but has no axially extending member such as a spacer tube 30 or spindle 16 therethrough. The transfer aperture 79 between separation chamber 80 and outflow chamber 81 is now circular, centred on the rotation axis, rather than annular. Accordingly, the pressure responsive, flow check valve 82 comprises a valve member 83 which is circular in plan view. Preferably, but not necessarily, the upper surface of the valve body defining the valve face is inclined with respect to the rotation axis, as described for the annular forms above, to provide a smooth flow path between the chambers across the seating region of the partition wall.

CLAIMS

1. A self-powered centrifugal separator rotor comprising a container operatively rotatable about a rotation axis extending therethrough, the container having
(i) an outer peripheral wall,
(ii) an internal partition wall extending radially inwardly from the peripheral wall dividing the container into a separation chamber and an outflow chamber and defining at its radially inner periphery a transfer aperture between the separation and outflow chambers, said separation chamber including an inlet port to admit liquid thereto from the rotation axis and the outflow chamber having at least one tangentially directed reaction jet nozzle to eject liquid from the container, and
(iii) a pressure responsive check valve operable to close the transfer aperture when the pressure of liquid in the separation chamber is below a predetermined value, the valve comprising a valve body contained within the outflow chamber, bias means operable to bias it in an axial direction towards the transfer aperture and a valve seat formed by the partition wall,
the partition wall having at least a portion thereof, surrounding the transfer aperture, formed with the face thereof defining the outflow chamber inclined with respect to the rotation axis at an acute angle such that the said inclined partition face forms a seating region for the valve body, the valve body comprising a radially extending valve face disposed overlying said transfer aperture and seating region and defining therebetween a valve passage which includes said inclined partition face, said valve body being responsive to said bias means to abut said seating region of the partition face to close said valve passage.

2. A centrifugal separator rotor as claimed in claim 1 in which the valve face comprises a surface of the valve body inclined with r spect to the rotati n axis.

3. A centrifugal separator rotor as claimed in claim 2 in which the surface of the valve body defining said valve face is inclined with respect to the rotation axis at a substantially constant angle.

4. A centrifugal separator rotor as claimed in any one of claims 1 to 3 in which said portion of the partition wall surrounding the transfer aperture defines a seating region inclined at a substantially constant angle with respect to the rotation axis.

5. A centrifugal separator rotor as claimed in claim 4 in which the partition wall radially outwardly of the seating region and defining said outflow chamber is inclined with respect to the rotation axis at substantially the same acute angle as the seating region.

6. A centrifugal separator rotor as claimed in claim 4 or claim 5 when dependant on claim 3 in which the valve face and seating region are inclined with respect to the rotation axis at substantially the same angle.

7. A centrifugal separator rotor as claimed in any one of claims 2 to 5 in which, in an elevational plane extending through the rotational axis, one of the valve face or seating region of the partition face is convex towards the other face and said other face is inclined at a substantially constant angle with respect to the rotation axis.

8. A centrifugal separator rotor as claimed in any one of the preceding claims in which the surface of the at least one of the valve face and seating region carries thereon a seal enhancing material.

9. A centrifugal separator rotor as claimed in claim 8 in which the seal enhancing material comprises a resilient coating deposited on the surface of the said valve face or s ating region within the valve passage.

10. A centrifugal separator rotor as claimed in any one of the preceding claims in which both of the partition wall and valve body are moulded from sheet materials deformed to shape.

11. A centrifugal separator rotor as claimed in claim 10 in which at least one of the valve body and partition wall is moulded from steel sheet pressed to shape.

12. A centrifugal separator rotor as claimed in any one of the preceding claims in which the rotor includes, at least in operation, a cylindrical member extending along said rotation axis between spaced bearings in the peripheral wall, said member defining a radially inner wall for both chambers and an annular transfer aperture, and the valve body comprises an annular body surrounding, and slidable along, the cylindrical member.

13. A centrifugal separator rotor as claimed in claim 12 in which the annular valve body has an axially extending sleeve part surrounding the cylindrical member and providing therewith, a sliding fit substantially liquid-tight between its ends at a pressure difference below that at which the bias is overcome.

14. A centrifugal separator rotor as claimed in claim 13 in which the axially extending sleeve part of the valve body is mated with the member to provide minimum clearance therebetween for passage of said liquid.

15. A centrifugal separator rotor as claimed in claim 13 or claim 14 including a seal member disposed between the cylindrical member and surrounding axially extending sleeve part.

16. A centrifugal separator rotor as claimed in any one of claims 12 to 15 in which the rotor is arranged in operation to rotate about the cylindrical member and the sleeve part of the valve body includes bearing means co-operable with

the cylindrical member to p rmit relative movement of the valve body along and about the cylinder member.

17. A centrifugal separator rotor substantially as herein described with reference to and as shown in, any one of the accompanying drawings.

18. A self-powered centrifugal separator including a source of liquid at elevated pressure, a rotor as claimed in any one of the preceding claims and a pressure-responsive liquid supply valve operable to prevent supply of liquid to the rotor at a source pressure below a predetermined minimum, and wherein the rotor check valve bias means is arranged to close the valve passage to liquid flow against a pressure difference, between the separation and outflow chambers, less than said predetermined minimum source pressure.

19. A method of manufacturing a self-powered centrifugal separator rotor as claimed in claim 14 comprising forming the cylindrical member as a tubular body, disposing the axially extending sleeve part of the valve body about the cylindrical member and radially expanding the member into mating sliding engagement with the sleeve part.

The Patent Office

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Claims searched:	1-19	**Date of search:**	3 October 1995

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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.N): B2P

Int Cl (Ed.6): B04B 9/06

Other: Online databases: EDOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 2283694 A	(The Glacier Metal Co. Ltd.) Whole document	
X	GB 1532409 A	(The Glacier Metal Co. Ltd.) Whole document: use of valve 33.	1-19
A	EP 0193000 A	(AE plc) Whole document	

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Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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